ACTIVITY REPORT

November 2003

Natural Gas & Oil Technology Partnership

Bringing Department of Energy national laboratories capabilities to the petroleum industry.

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Note: Natural Gas and Oil Technology Partnership projects are reported according to the following schedule:

January, March, May, July, September, November	**February, April, June, August, October, December**
Drilling, Completion, and Stimulation Technology Oil and Gas Recovery Technology Diagnostic and Imaging Technology	Upstream Environmental Technology Downstream Environmental Technology Natural Gas Technology

Natural Gas and Oil Technology Partnership on the World Wide Web: http://www.sandia.gov/ngotp/

Drilling, Completion, and Stimulation Technology

Downhole Seismic Source for Look-Ahead Pore Pressure Prediction While Drilling

(Halliburton and INEEL)

No report received.

Acoustic Telemetry (MWD) Drilling

(ABB, Electroacoustics Research Laboratory, Extreme Engineering, and SNL)

Highlight:

- Telemetry model improved.

Several modifications have been made to copyright software that models the acoustic telemetry system. Most importantly, a new damping mechanism has been added that more accurately models the attenuation of telemetry signals propagating through drill strings.

Effects of Well Conditions on Post-Perforation Permeability

(Halliburton, Penn State, and LLNL)

Highlights:

- Extended the computational model to simulate the experiments in large cores used for the recently completed systematic experiments conducted at JRC.
- Ongoing efforts are aimed at calibrating the computational model to the range of experimental results provided by JRC and PSU.

Integrated experimental and computational efforts have led to new insights into the role of underbalance and rock properties on post-perforation permeability. X-ray CT scans of cores of Berea sandstone and Bedford limestone perforated at a range of underbalance pressures highlight the importance of rock properties on perforation clean-up. In sandstone, increasing underbalance leads to a reduction in charge debris remaining in the perforation and enhanced permeability, whereas in limestone, remaining charge debris and permeability are insensitive to underbalance.

A perforation simulator has been developed that simulates the alteration of rock permeability due to shaped-charge-jet penetration and the subsequent clean-up of the perforation tunnel. This model is based upon earlier work from this project that led to the development of a constitutive model for the permeability evolution of deforming Berea sandstone. Comparison of measured core flow efficiencies and perforation tunnel geometries to simulations demonstrates that the computational model predicts perforation clean-up in the sandstone cores reasonably well.

Publications

Submitted two papers detailing experimental and computational results for presentation at the upcoming SPE International Symposium and Exhibition on Formation Damage Control.

Lifetime Performance Monitoring of Synthetic Fiber Mooring Ropes

(Petroleum Composites, Puget Sound Rope, Shell, Whitehill Manufacturing, and ORNL)

Work is being completed on the fiber integration methodology, including techniques for fiber ingress/egress in the rope assemblies. Whitehill Manufacturing is in the process of inserting the fiber into a braided subrope. Stress tests on the rope assembly should be performed at Whitehill's Manufacturing facility in December. Results of this effort should be available at the end of the next reporting period.

Automatic Flaw Detection and Identification for Coiled Tubing

(U of Tulsa, INEEL)

No report received.

Laboratory Study on Borehole Stability and Sand Production in Weakly Cemented Sand

(ChevronTexaco, Shell, and LBNL)

The logging frequency acoustic device has been tested using a reference acrylic core and uncemented silica sand under a range of confining stresses. Using a numerical code, the elastic moduli and attenuation coefficient of the acrylic core with known material properties were successfully extracted at near 1 kilohertz. Measurements on the silica sand cores also produced very reasonable values, although there are no other measurements to compare the results. Additional code that determines the elastic properties of test cores from higher frequency wave propagation test results is under development. Tests will continue with pore fluid and intergranular cement in the samples to determine the elastic moduli of weakly cemented sand blocks used in sand production experiments.

During this report period, as a part of the deliverables of this project, LBNL also produced an activity report including the results of two-dimensional borehole breakout experiments, detailed designs of the logging-frequency acoustic measurement device, and a "true" triaxial loading cell used for sand production experiments. The report is currently circulated among the industry partners.

Development of Smart-Proppant Technology for Hydraulic Fracturing

(U of Tulsa and INEEL)

As previously reported, the liquefaction of guar associated with a volunteer culture is superior to microorganisms purchased to date. The current hypothesis is that the enzymatic systems responsible for guar degradation are inducible and not constitutive. Biomass has been prepared and shipped to the University of Tulsa for encapsulation in appropriate carrier beads for further evaluation. Information on the development and characterization of the carrier material has been previously reported.Organisms were prepared by growth in one-half strength trypticase soy broth for 24 hours at 60°C followed by triplicate washing in 0.1 M phosphate buffer at pH 7.0. Previous studies have demonstrated that following growth on dilute synthetic media, the cells are capable of guar degradation after a prolonged lag phase. Initial encapsulation will be during the manufacturing process of the beads. Manufacture should be complete by the second week of December.

Application of High-Powered Lasers to Drilling and Completing Deep Wells

(Parker Geosciences, Colorado School of Mines, Gas Technology Institute, Halliburton Energy Services, and PDVSA, and ANL)

Highlights:

- CO_2 laser multispot rock drilling test successful
- Lowest specific energy or highest rock penetration rate was recorded for some rock samples.
- Safe containment enclosure for CO_2 laser has been installed.

The team met at Argonne National Laboratory on the week of November 3 -7 and carried out a test series on CO_2 laser multi-spot drilling of rocks. Objectives were to increase rock penetration rates while maintaining a large shallow hole condition, and to simulate a multi-beam configuration more closely by reducing relaxation time without problems associated with starting and stopping sample movement. The team successfully achieved the objectives.

In previous Nd:YAG laser tests, rock samples were moved under the laser beam in a triangular pitch pattern. In the tests reported here, the rock samples were rotated under a fixed CO_2 laser beam. The rock motion spread out the holes during rotation. The spot size was larger than in previous testing by about 50%, which reduced the amount of power at each point, therefore reducing melting of the rock. Reservoir type rocks, not just "perfect" samples, were tested, which gave variable results. The results were, for some samples, the lowest specific energy [energy required to remove unit volume of rock (J/cm3)] recorded so far and extremely smooth holes (no ridges) were also produced. The test data further proved that the multiple shallow spot configuration

concept can be used to efficiently drill large diameter and deep holes in rocks. The tests also showed conclusively that the longer wavelength of the CO_2 laser beam coupled better with some of the samples (shale, in particular), and produced melting when not expected. Shale must be cut with almost no power input. This test series continued the work showing that limestone is not an "energy hog" as our early work indicated, but needs close control on parameters to cut very efficiently.

During the reporting period, construction materials for a safety enclosure for the CO_2 laser were ordered and the installation of the enclosure was finished. With the enclosure in position, personnel and equipment are well protected while allowing testing of lenses, gas purge, and fiber designs on dry and saturated rock samples. Team members also actively participated in profession conferences and presented the laser rock drilling R&D results to the laser and petroleum industry communities. Companies such as Saudi Aramco, Petroleo Brasieiro, Schlumberger and Core Lab expressed strong interests in being new industry partners on laser rock drilling research.

Publication

R. A. Parker, B. Gahan, R. M. Graves, Z. Xu, C.B. Reed, "Laser Drilling: Effects of Beam Application Methods on Improving Rock Removal," 2003 SPE Annual Technical Conference and Exhibition, 5 - 8 October in Denver, Colorado, SPE Paper 84353.

Oil and Gas Recovery Technology

Measuring Sucker Rod Pump Parameters Downhole

(Harbison-Fischer, UT-Austin, and SNL)

Highlight:

- Instrumented pump for Texas Tech fabricated

The pump fabricated by Harbison-Fischer for Texas Tech has been checked out and minor changes are being made. Miscellaneous parts are being acquired. The unit will be ready by April when Texas Tech plans field testing.

Direct Simulation of Near-Wellbore Mechanics

(ChevronTexaco, Halliburton, Schlumberger, Shell, MIT, NM Tech, and SNL)

Highlight:

- Completed a collaborative proposal with Professor Haimson of the University of Wisconsin to apply the DEM code to the numerical simulation of borehole breakout mechanisms in various sandstones

In addition to continued code development and wellbore modeling efforts, a collaborative proposal has been developed with Professor Haimson of the University of Wisconsin to apply the Discrete Element Method (DEM) code to the numerical simulation of borehole breakout mechanisms in various sandstones. The proposed research leverages Professor Haimson's experimental expertise and knowledge of breakout phenomena and strengthens our NGOTP project by providing direct comparison of our numerical results to laboratory data. If funded, the Haimson collaboration will provide the NGOTP project with supplementary funding to support Haimson's research group on the development of synthetic DEM models of various sandstones, and the subsequent simulations of borehole breakout. It is believed that the Haimson collaboration strongly compliments the NGOTP project and provides significant value (at no cost) to industry partners by extending the model's validation base.

Research work during this period continued to focus on two activities: 1) the development and testing of 2D model specimens for sanding simulations; and 2) the integration of the 3D fluid solver with the 3D DEM code. In addition to the PI, project staff contributing during this period included graduate interns Dave Boutt (NMT) and Scott Johnson (MIT), as well as postdoctoral associate Erik Strack.

The first set of sanding simulations has been completed. This uses two different distributions of particle shapes, angular and round, which allows evaluation of effects of particle shape on simulated sand production. As one might intuitively expect, the round particle models yield significantly higher sanding rates than the angular particle models, which resist fluid erosional forces through particle interlocking.

Several other models are under development to evaluate the effects of cohesion (interparticle cement) and varying confining stress. As reported in the last update, early validations with the 3D code exhibited some discrepancies from expected behavior for moving solids tests. Two subtle implementation errors have identified and corrected . Several additional moving particle validations are currently being performed, and early results are encouraging.

Well Integrity Assurance for Sub-Salt and Near-Salt Deepwater GoM Reservoirs

(BHP, BP Amoco, ChevronTexaco, ConocoPhillips, ExxonMobil, Halliburton, Kerr-McGee, Shell, and SNL)

Highlight:

- Paper published and presented

SPE 85445 "Stress Perturbations Adjacent to Salt Bodies in the Deepwater Gulf of Mexico" by Fredrich, Coblentz, Fossum, and Thorne was published and presented at the recent SPE ATCE. The paper describes the 3D non-linear finite element geomechanical modeling performed to analyze the in-situ stress state existing in, and adjacent to, salt bodies before drilling, as well as under producing conditions. The paper presents four idealized deepwater Gulf of Mexico geometries including a spherical salt body, a horizontal salt sheet, a columnar salt diapir, and a columnar salt diapir with an overlying tongue. The analyses reveal that at certain locations for specific geometries:

1) shear stresses may be highly amplified,

2) horizontal and vertical stresses may be significantly perturbed from their far-field values,

3) principal stresses may not be oriented vertical and horizontal (i.e., the vertical stress may not be the maximum stress); and

4) anisotropy in the horizontal stresses may be induced.

For some geometries, the vertical stress within and adjacent to the salt is not equal to the gravitational load; i.e., a stress-arching effect occurs. Analogously, the assumption that the horizontal stress within a salt body is equal to the lithostatic stress is sometimes incorrect. The modeling suggests an alternative explanation for the so-called rubble zones thought to occur beneath and/or adjacent to salt diapirs in that they may be an intrinsic consequence of the equilibrium stress field needed to satisfy the different stress states that exist within the salt body and in the non-salt surrounding formations.The paper also demonstrates with an example how the modeling can enable more rigorous planning of well locations and trajectories by providing more accurate estimates of the vertical and horizontal stresses around and within salt bodies for wellbore stability analyses so as to avoid areas of potential geomechanical instability, and to enable accurate fracture gradient predictions while entering, drilling through, and exiting salt bodies.

Work continued on development of a software tool for predicting time-to-closure for through-salt circular boreholes as well as time-to-contact and time-to-yield for elliptical through-salt boreholes. The tool will directly enable in-house application of the wellbore scale modeling to be directly applied by industry partners to aid in well casing design. This software is to be delivered to the industry partners at the next partners meeting scheduled for January 2004.

Petrobras S.A. expressed interest in formally joining the project and a contract is being executed. The terms of their participation are similar to that with the other seven industry partners.

An Integrated Approach to Assessing Seismic Stimulation

(Aera Energy, ASR, BP Amoco, ChevronTexaco, ConocoPhillips, Halliburton, Marathon, OGCI, Piezo Sona-Tool, Schlumberger, Shell, UC-Berkeley, LBNL, and LANL)

Field tests of seismic stimulation tools are being conducted in various oil fields to gauge the effectiveness of the individual tools and the technique itself. Lawrence Berkeley National Laboratory, as part of an integrated laboratory, field and theoretical research project, has been conducting field monitoring of various stimulation sources at different locations. At Lost Hills, two separate studies are being conducted using a downhole fluid pulsation device developed by Applied Seismic Research Corp. (ASR). One site is operated by AERA Energy LLC and the other is operated by ChevronTexaco USA. Initial field work in Lost Hills at the AERA site was able to monitor the ASR source at close distance. Field work in October 2003 successfully monitored the ASR source at large distance at the Chevron site. The combined data sets allowed useful analysis of the source.

The monitoring tool is a modified wall-locking 3-C geophone in which one horizontal geophone component was replaced with a borehole hydrophone. The hydrophone measures borehole fluid pressure while the remaining two geophones (vertical and horizontal polarization) measure velocity of the formation (assuming mechanical coupling of the formation-to-casing and casing-to-the-tool via the locking arm). In principle, the geophone measures elastic waves at the borehole, while the hydrophone measures fluid pulses transferred to the borehole fluid through casing perforations, as well as elastic waves converted to fluid pressure at the borehole wall.

To date the relevant observations are:

1) Source generated energy, above background noise, was observed in the monitoring well at a distance of about 920 ft.

2) Energy arriving before the tube-wave appears to be waves propagating in the reservoir at or near shear-wave velocity.

4) The hydrophone data has a high frequency (100-200 Hz) arrival associated with the body waves.

5) Lower noise levels (both random and tube-wave) in the perforated interval increased detectability of the high frequency arrival.

6) RMS pressure levels of the seismic waves are about 2 Pa (dominated by the tube-wave) and about 0.03 Pa after a 120 to 30 Hz band pass filter.

7) RMS ground motion levels are about 1.5×10^{-7} m/s on horizontal and vertical components.

8) Maximum strain levels are about 1.5×10^{-9} in the reservoir (calculated for a 10 Hz dominant frequency, which corresponds to the high amplitude tube-wave arrival).

In terms of interpretation the most important observation was the high frequency signal observed on the pressure transducer in the perforated zone of the observation well. It had a the velocity of a shear wave , but was not detected on the clamped horizontal component of the geophone. The diatomite has the shear wave velocity near the velocity of fluid so it is difficult to separate the two velocities. If this is the pressure wave traveling through the fluid then this is a significant finding and implies that the pressure pulse is efficiently transmitted through the formation. If this is true then there will be a dilation of the pore spaces and an increase in pore size thus allowing an increase in permeability.The obvious next step is to model the effect of the pressure increase for the diatomite and integrate over the affected volume. If possible the next set of measurements should be at an intermediate distance and in a well with either a tube wave damper or the fluid level drawn down a few hundred feet such that the tube wave is minimized.

Direct Quantification of Uncertainties Associated with Reservoir Performance

(ChevronTexaco and LANL)

Highlight:

- Karhunen-Loeve decomposition improves solution accuracy at reduced computational costs

A newly developed methodology based on Karhunen-Loeve (KL) decomposition has made a revolutionary change in quantifying uncertainty in reservoir performance. The algorithm has been tested for two-dimensional problems and results show that this method is superior to both Monte Carlo simulations and the moment-based method (which was proposed in the original proposal) in computational costs and solution accuracy. This approach makes it possible to evaluate reservoir performance at large scales.

Work continues on extending 2D codes to 3D codes, and will also explore how to determine the minimum of terms retained in the KL decomposition while still keeping the desired accuracy.

Diagnostic and Imaging Technology

Next-Generation Seismic Modeling and Imaging

(Advanced Data Solutions, Anadarko, BHP Petroleum, BP Amoco, ChevronTexaco, Conoco, Core Laboratories/Tomoseis, ExxonMobil, Fairfield Industries, Fugro Geoservices, GeoCenter, Geophysical Development, GX Technology, Marathon, Mitchell Energy, Paradigm Geophysical, PGS, Phillips, Shell, Unocal, Veritas DGC, WesternGeco, Society of Exploration Geophysicists, Stanford University, University of Houston, LANL, and LLNL)

No work scheduled during the reporting period.

Rapid Imaging of Interwell Fluid Saturations Using Seismic and Multiphase Production Data

(BP Amoco, ChevronTexaco, ConocoPhillips, ExxonMobil, JNOC, Landmark, RC2, Statoil, Tomoseis, Total-Fina-Elf, Texas A&M, and LBNL)

No report received.

Offshore Oil Field Characterization with EM Methods

(Scripps, Texas A&M, and SNL)

Highlights:

- Half-day meeting with Scripps
- Met with SIO consortium to discuss progress and future
- 2D code in final testing
- 2.5D code presently under development
- University of Utah providing some needed modeling support

During the recent annual meeting of the Society of Exploration Geophysicists (SEG), SNL team members participated in a short, half-day project meeting with Scripps Seafloor Electromagnetic Consortium members. The goal of the meeting was to present a progress report on the status of the Scrips Institute of Oceanography (SIO)/SNL marine hydrocarbon exploration work, and to get feedback from consortium members on the direction of future work. The membership says that modeling is still important and strongly desired and current research strategy should proceed. A 2D magnetotelluric forward modeling code based on unstructured finite element meshes has been developed which allows for accurate representation of seabed bathymetry and irregular boundaries between lithologic units. Final testing of the adjoint derivative calculations are being conducted at SIO.

In addition, a 2.5D controlled source modeling code is being developed and availability within 3-4 months is anticipated. At this point a significant short-term goal of the project can be addressed - to jointly invert the magnetotelluric and controlled-source data collected over Gemini in Jan/Feb 2003. In the meantime, the University of Utah modeling group (Michael Zhdanov et al.)

has stepped forward to provide modeling support not presently available by the SNL team.

Innovative Wave-Equation Migration

(Advanced Data Solutions, Amerada-Hess, Applied Geophysics Services, Baker Atlas, BHP, ConocoPhillips, ExxonMobil, FairfieldIndustries, GX Technology, Petroleum GeoServices, Screen Imaging, Shell, TomoSeis, Unocal, Veritas DGC, and LANL)

Highlight:

- Progress reported at Society of Exploration Geophysicists Meeting

LANL researchers delivered two oral presentations at the 73rd Society of Exploration Geophysicists (SEG) annual meeting held in Dallas, Texas, October 26-31. One presentation was on a new imaging condition that produces migration images whose amplitudes could provide useful physical properties of materials across an interface. Another presentation was on controlled-aperture wave-equation migration that can improve the efficiency and accuracy of common-shot wave-equation migration.

At the SEG meeting, Lianjie Huang also chaired a session on "Migration Amplitude Studies". LANL researchers continued the implementation of their recently developed 3D stationary-phase wave-equation migration method. A synthetic 3D narrow-azimuth dataset from the SEG/European Association of Geoscientists and Engineers salt model was used to test the new method. A 3D wave-equation migration of a 3D field dataset was investigated to reduce image noises due to large cross-line intervals in the data, and large grid spacings used during migration. At the same time, research commenced on improving computational efficiency of 3D wave-equation migration, which is a critical issue for practical applications.

Testing and Validation of High-Resolution Fluid Imaging in Real Time

(DeepLook, KMS Technologies, KJT Enterprises, U of Wisconsin, LBNL, and SNL)

Highlight:

- A summary of results and ongoing progress for this project was presented to the petroleum industry at the recent annual International Meeting of the Society of Exploration Geophysicists in Dallas, Texas

A summary of results and ongoing progress for this project was presented to the petroleum industry at the recent annual International Meeting of the Society of Exploration Geophysicists in Dallas, Texas. Industrial collaborator Dr. Kurt Strack delivered a talk entitled "Real Time Fluid Imaging With An Integrated Single-Well Seismic/EM System" (by E. Majer, R. Ostermeier, and K. Strack) at the convention workshop on "Real Time Drilling Decisions". The presentation highlighted progress by LBNL and Shell in fielding a combined seismic and electromagnetic single-well data acquisition system. Also, three-dimensional computational simulations conducted by SNL of seismic and electromagnetic responses of various single-well acquisition tools were reviewed.

LBNL and SNL, in collaboration with Shell and KMS Technologies, are currently developing a third-year project continuation proposal for submission to NGOTP. Two critical issues that will be investigated via numerical modeling of tool electromagnetic and seismic responses are detectability of near-borehole fluid concentrations, and determining the azimuth to a localized fluid anomaly. Although the "azimuthal ambiguity" problem has been considered inherent (and intractable) in a single-well data acquisition geometry, it may be resolved by recording a combination of multi-component seismic and EM data.

Autonomous Monitoring of Production

(Aera Energy, ChevronTexaco, SteamTech Environmental Services, TomoSeis, and LLNL)

A remotely-controlled electric resistivity tomography (ERT) data acquisition system has been tested and deployed in the field, capable of obtaining full time-lapse datasets on command. The system worked well under normal envi-

ronmental conditions. The system continued to operate even during the summer when temperatures inside the data acquisition trailer were over 100^{o}F.

There were intermittent problems contacting the system during some periods. It is believed this was due to periods of high winds which moved the communications dish ever so slightly so that it no longer pointed at the satellite. Communications were reestablished when the dish returned to the correct position after the wind storm.

More serious problems were experienced during electrical storms at the site. After some of these storms it was impossible to reestablish contact with the system. When this happened, it was necessary to personally troubleshoot the problem. Diagnostics regularly sent from the site to the remote control location are being evaluated to determine the cause of these outages.

The major difficulty was caused by severe electrical storms at the site in the late summer of 2003. These produced high winds and lightning-induced electrical surges in measurement lines as well as the utility power cables. The electrical surges burned out fuses in some equipment and burned traces off of IC boards in other equipment. This was not a temporary interruption but required a trip to the site to repair the damage. Electrical surges in the utility power actually destroyed a power pole transformer requiring the system be shut down until the damage was repaired by the power company.

These problems are being studied to determine the best method to solve each one. The initial response was to disconnect the data system from utility power and from the oil field. This course of action protects the electronics but then makes it difficult to remotely operate the measurement system. Other solutions exist that don't require a personal site visit.These options are being examined.

Anisotropic Properties of Compacted Clay-Rich Rocks

(BP Amoco, ChevronTexaco, ConocoPhillips, and LBNL)

During this period, fabrication of two broadband shear wave receivers were completed and tested. Transmission tests on clay samples using a shear source driven with a Ricker wavelet demonstrated that these receivers possessed clean, nonresonant performance up to the target of 50 kHz. With the completion of the shear wave receivers, the first set of anisotropy measurements on compacted clay were acquired using the uniaxial strain compaction cell.

The clay sample, provided by ChevronTexcaco, is a stiff clay taken from a shallow geotechnical core. Measurements of the compressional wave were obtained by synthetically phasing plane waves at different angles. These measurements were performed using the 32 element (1-3 piezocomposite, 1 MHz) P-wave array located in the base of the confining cell as the source, and a pinducer located in the loading piston as the receiver. The data corresponds to a condition of uniaxial strain loading at an axial stress of 4 MPa with atmospheric pore fluid pressure (drained loading).

These data, together with the compressional wave and vertically and horizontally polarized shear wave data measured along the bedding using three sets of transducers located in the compaction cell walls, were used to compute the 5 transverse anisotropic elastic constants, and to reconstruct the slowness surfaces of the quasi-compressional wave and the two quasi shear waves.

Because of the unique design of this acoustic anisotropy confining cell, it is believed that it is now possible to perform routine measurements of stress-induced anisotropy in compacting clay rich rocks during compaction without the need for sample unloading and coring that is required in the standard approach for measuring anisotropy in laboratory samples. A series of tests is planned on geotechnical core that will be provided by ChevronTexaco from a site in Angola.

Realistic Anisotropic Velocity Estimation in Complex 3D Environments

(BP Amoco, ChevronTexaco, ConocoPhillips, Kerr-McGee, Shell, TomoSeis, and LBNL)

An implicit finite-difference migration method in VTI media has been developed. As in most one-way wave equation migration methods, this method cannot handle evanescent waves as it causes instabilities and inaccuracy. A complex Padé approximation to the exponential operator has been proposed. This method can significantly reduce the inaccuracy and instability problem. Future work will consider the use of a higher order Padé approximation to the exponential operator.

A 25-point finite difference code has been developed that uses a radial basis function on a regular mesh for the full anisotropic wave equation. This method has less dispersion compared with conventional staggered grid finite difference methods, so coarse grids can be used. Future work will apply this method to complex velocity models with irregular interfaces.

Joint Geophysical Imaging

(ChevronTexaco, Core Laboratories, Electromagnetic Instruments, ExxonMobil, and SNL)

Highlights:

- Presented a poster paper on the joint inversion of crosswell EM and seismic data
- Work on a version for publication is on-going

Progress on the joint EM/seismic inversion project has been steady. The 3D EM inversion code based upon non-linear conjugate gradients is being improved. An efficient restart capability has been implemented for large inversion runs using saved conjugate gradient search directions from previous inversion iterations. Previously the algorithm had to be restarted using the steepest descent direction resulting in poorer convergence of the inversion iteration. Testing continues on a new limited memory quasi-Newton method to see if faster convergence can be achieved. These codes are now optimized for analyzing large-scale problems that arise in sea-bed logging problems for fluid mapping of oil and gas reservoirs. The codes are being used to analyze a marine sea-bed logging data set provided by Shell Oil company.

On the seismic side of the joint inverse, considerable time has been spent understanding the current state of the art in amplitude versus offset (AVO) inversion used within the petroleum industry. A number of linear and non-linear AVO inversion algorithms parameterized in both time and depth have been developed. Some of the AVO inversion algorithms have been used in a paper under review in *Leading Edge* entitled "Study of Gas Hydrates in the Deep-Sea Gulf of Mexico From Seismic Data". The depth inverse is required for coupling with the EM data since the EM modeling is done at depth.

Work continues on the first joint AVO-EM inversion algorithms in 1D. Both a deterministic and a stochastic 1D inverse are under development. These algorithms should begin testing within 1 to 2 months. They will provide a fast test-bed for the effects of errors in the rock-properties model (that links the geophysical parameters of the different techniques) on the accuracy of joint inversion.

Publication

A poster paper was presented on the joint inversion of crosswell EM and seismic data at this years SEG entitled "Joint Stochastic Inversion of Geophysical Data for Reservoir Parameter Estimation". Work on a version for publication is on-going.

Partnership Office

FY04 Partnership Review Process set for Diagnostics and Imaging Technology, Oil and Gas Recovery Technology, and Drilling Completion and Stimulation Techology.

This year's process is similar to the preproposal review process used in the past for new proposals. Reviews of projects will be done by their respective industry panels (e.g., a DIT project will be reviewed by the DIT panel) All continuing projects from FY2003 are eligible to submit a continuation proposal. The partnership confirms funding the three selected new starts at $250K (minus their pro rata taxes). The Gas Issues Forum Project will be funded at FY03 levels as directed by DOE (minus their pro rata taxes).

Calendar
Dec. 19th, 2003 -Three-page proposals due to the respective forum leader
Jan. 5th, 2004 - Proposals sent to review panels
Jan 23rd, 2004 - Proposal reviews return to forum leader
Jan 26th, 2004 - Partnership teleconference to review scores, address issues, and make funding recommendations
Jan 30th, 2004 - Results forwarded to DOE